CORRESPONDENCE

Comments on "Gravitational Tidal Forces and Atmospheric Processes"

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The suggestions of Visvanathan [2] should be helpful in clearing up some of the misunderstandings or misinterpretations of the physical-statistical type mechanism presented in my earlier paper [1]. It was felt by some readers that the general applicability of the model to the real world depends upon the validity of the assumptions that F_c is a constant or that force F varies linearly with time. It is clear that no such restrictions are necessary. The paper also pointed out, although perhaps not explicitly, that in relating the phase of a small perturbation to the time of occurrence of a relatively rare or *extreme* event, it is not even necessary to postulate the existence of a critical level F_c or a change in state of a system. The demonstration was made for the case in which forces F and f are periodic with amplitudes A and a, respectively, with $A>>a$. It was shown that the time of occurrence of an *extreme* event E is essentially independent of the relative amplitude A/a. It is possible to show this in the more general case wherein F and f are not necessarily periodic in time. Suppose that F and f are observed at times $t_1, t_2, \ldots t_n$ and that E depends upon the sum

$$S_t=F_t+f_t \tag{1}$$

being large or extreme at some time t. Figure 1 shows a scatter diagram, in which the heavy sloping line represents a fixed sum of F and f. The extreme values of S, lying to the right of this line, are extreme because both F and f are extreme. The slope of this line can be changed by assigning unequal weights w_1 and w_2 to F and f, respectively, resulting in a function

$$S'=w_1F+w_2f. \tag{2}$$

It is obvious that the most extreme values of S' are approximately the same observations as the extreme values of S, or in other words, the relative weights for F and f are not especially important for events E.

There is a further puzzling aspect of the lunar-precipitation relation which may seem to require further elaboration. How can any factor affect rainfall by as much as 10 or 20 percent and still have a correlation so low as to account for only a small fraction of the variance in the rainfall series? Rainfall distributions, such as daily or storm totals, are known to be very skewed with the standard deviation σ approximately equal to the mean $\overline{R}$. If the amplitude of a periodic perturbation fitted to rainfall data is a, then the relationship between a and the correlation coefficient r is given by

$$r^2=\frac{a^2}{2\sigma^2}. \tag{3}$$

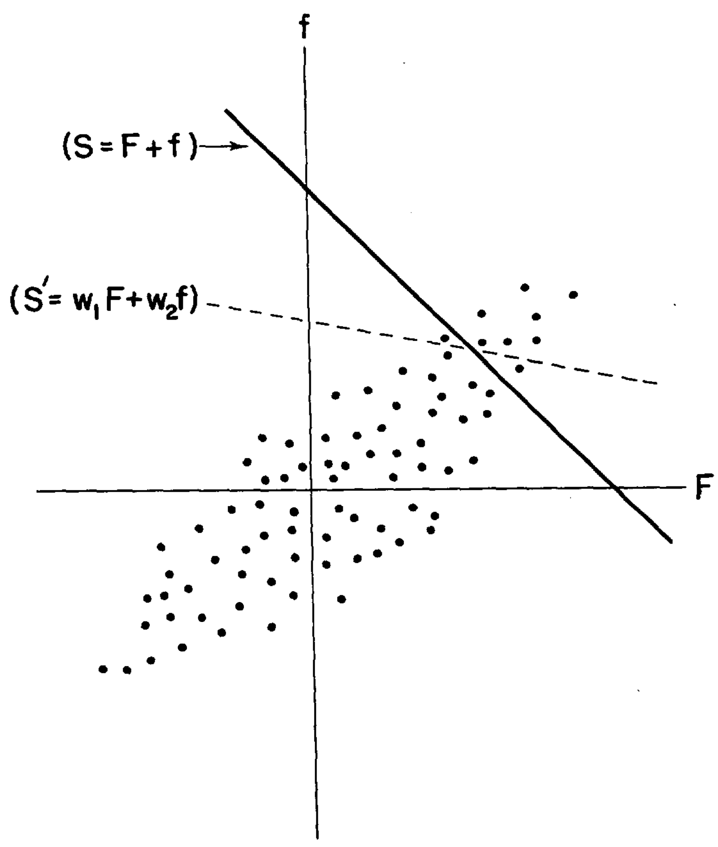

Figure 1.—Scatter diagram of events (dots) as a function of forces F and f.

If for convenience we take $\overline{R}=\sigma=1$ and choose a reasonable value of $a=1/10$, we find that $r^2=0.005$. This means that a perturbation (either natural or man-made) that could affect rainfall by ± 10 percent would account for only ½ of 1 percent of the variance and probably would be detected only with a long data series. Often there is a tendency to equate low correlations (even though statistically significant) with lack of physical importance or to conclude that factors that have minor usefulness as predictors produce no results of practical social or economic consequence. However, there may be circumstances, such as in attempts to artificially modify the weather, when a rainfall increase of 10 or 20 percent could be of great value. We must be careful not to confuse statistical significance with physical significance and not to confuse the coefficient of determination r^2 with practical or economic importance.

REFERENCES

1. G. W. Brier, "Diurnal and Semidiurnal Tides in Relation to Precipitation Variations," *Monthly Weather Review*, vol. 93, No. 2, February 1965, pp. 93–100.
2. T. R. Visvanathan, "Gravitational Tidal Forces and Atmospheric Processes," *Monthly Weather Review*, vol. 94, No. 5, May 1966, pp. 307–310.

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